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ZONING MAPS FOR AIRPORTS

By Benjamin Everett Beavin, Sr., M. ASCE

SURVEYING AND MAPPING, AIR TRANSPORT DIVISIONS

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PAPERS

ZONING MAPS FOR AIRPORTS

By Benjamin Everett Beavin,[1] Sr., M. ASCE

Synopsis

Airport zoning may be defined simply as the protection of approaches. In practice, the term encompasses the defining of sloping approaches to standards evolved through long experience, and effectually protecting them from encroachment of man-made or naturally grown flight hazards by purchasing of adjoining land, securing avigation (aerial navigation) easements, or by enacting and enforcing zoning ordinances.

The purpose of this paper is to call attention to the desirability of early and effective zoning and to suggest methods of further simplifying and standardizing zoning surveys and maps.

An engineer engaged in the design and supervision of construction theoretically occupies a semijudicial position with definite responsibilities, not only to his client but also to the contractor whose work he oversees. Likewise, in zoning for airports, he has responsibilities to his client (usually somebody representing a segment of the general public) and also to those persons whose safety and properties are affected by whatever zoning measures are adopted.

Ideally, airport zoning should begin during the reconnaissance stage, before the site has been selected finally. The effect of the airport operations on neighboring properties should be weighed carefully. The noise factor should not be overlooked. Quite often a small rotation of all or part of a runway layout will result in greater approach clearances and therefore less property damage. It should be borne in mind constantly that a zoning ordinance, no matter how well drawn, cannot contravene the constitutional provision that properties may not be taken for public use without adequate compensation. Surely the act of restricting the heights of the structures that may be built in residential areas to something less than that of a two-story house, or fixing less than a reasonable height for a stack, water tank, or other necessary struc-

Note.—Written comments are invited for publication; the last discussion should be submitted by August 1, 1953.

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tures in industrial areas, may only be construed as a taking away of a considerable part of the value of properties so restricted.

It is not meant to suggest that airport zoning is bad, but rather to urge that public safety and property damage be considered along with all other factors in selecting the location for airports.

As soon as the site has been selected and the position and elevations of runway ends determined, four steps—(1) zoning of the airport, (2) purchasing of land in approach zones, (3) the securing of avigation easements (a comparatively recent development), or (4) a combination of all three—should be undertaken.

The importance of early and effective protection for airport approaches cannot be overstressed. The safety of passengers, neighbors, and aircraft and, indeed, the value of the entire project, may be jeopardized by the encroachment of flight hazards.

The preparation of zoning ordinances is a complex legal problem and should be undertaken in cooperation with competent legal counsel. Much useful legal information is readily available through the Civil Aeronautics Administration (CAA). The art of drawing legal descriptions of the zones, and the preparation of necessary zoning maps, calls for the highest order of engineering to insure that the resulting ordinance may be simple, clear, and easy to administer. Not so long ago approach and turning zones were defined by distances from irregular airport boundaries and by heights above runways of varying elevations. Zones so defined were scalloped in plan view, wavy in surface, and difficult to define mathematically.

Recent practice tends toward simplification of the geometrics of approaches, making the understanding, and successful administration, of a zoning ordinance much easier.

The best source of information concerning the avigation requirements naturally is the Civil Aeronautics Administration. Most of the zoning ordinances for civil airports have been guided by the administration's published material, the latest of which is *Technical Standard Order No. N 18*, issued on April 16, 1950. This order outlines the procedure for determining obstructions, defines imaginary governing surfaces, and limits the heights above

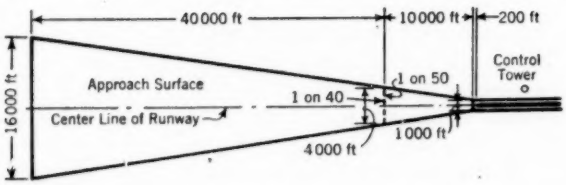

FIG. 1.—PLAN VIEW, APPROACH TO INSTRUMENT RUNWAY, INTER-CONTINENTAL TYPE OF AIRPORT (REGULATIONS, CIVIL AERONAUTICS ADMINISTRATION)

ground of objects in various areas at or near airports. Obviously, then, any suggestion as to further simplification of civil zoning practice must largely be a discussion of this technical order. In the text, the words or phrases in quotation marks are taken from the order.

The inclined paths followed by aircraft approaching or leaving runways are protected by the prohibition of the construction or maintenance of obstacles protruding through an imaginary inclined surface known as an "approach surface." That part of the earth directly below an approach surface is known as an "approach area" (Fig. 1).

In plan view the "approach surfaces" begin 200 ft outward from the end of the runway and, for instrument approaches, they are 1,000 ft wide, flare out to 4,000 ft wide at a distance of 10,200 ft from the end of the runway, and continue to flare out to a total width of 16,000 ft at a distance of 50,200 ft from the end of the runway. Non-instrument runway approaches vary in width according to the service classification of the airport. For instrument runways the approach slope ratio is specified by the CAA as 1 on 50 for the 10,000-ft section and 1 on 40 for the outer 40,000-ft section (Fig.2).

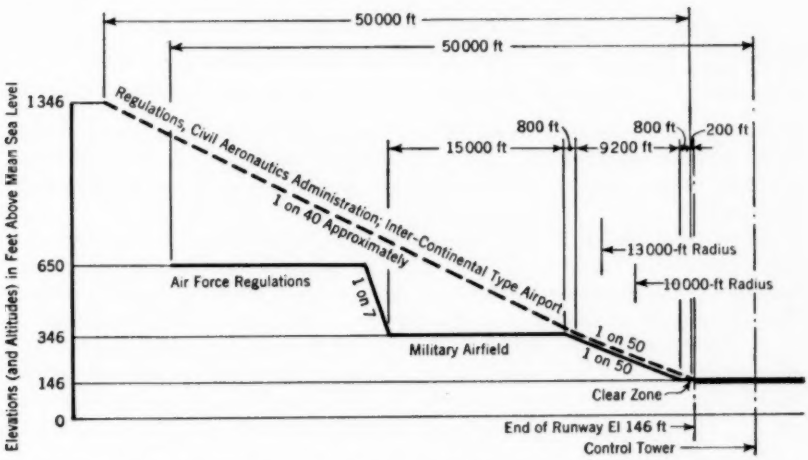

FIG. 2.—PROFILES OF APPROACH SURFACES, BASED ON AN ESTABLISHED AIRPORT ELEVATION OF 150 FT

The technical order can be simplified further by tabulating the widths and giving altitudes rather than slopes. For one reason, curvature of the earth amounts to approximately 60 ft in the 50,000 ft involved. Also, it is very desirable that the altitudes of imaginary surfaces, above mean sea level, be easily comparable with surface contours referred to the same datum. An improvement over present practice would be to tabulate the geometrics of approach surfaces as shown in Table 1.

The state coordinates should be given to fix the position of all runway ends horizontally. The ultimate ends should be protected, rather than intermediate stages of construction.

At first glance the values in Table 1 may seem to be the same as the current CAA regulations. However, a moment's reflection indicates that the current regulations are based on slope ratios referred to a plane tangent to the earth's surface at the runway end, whereas the tabulated values are obtained by

adding increments of altitude. By the slope-ratio method the altitude at the end of 50,200 ft would be approximately 1,260 ft instead of the 1,200 shown in Table 1. The error (due to using 2,000-ft intervals in part of the table) seems negligible; but, 1,000-ft intervals or smaller may be tabulated if so desired.

TABLE 1.—DIMENSIONS OF APPROACH SURFACES, INSTRUMENT RUNWAY, IN FEET

Distance[a] (1)	Width (2)	Height[b] (3)	Altitude[b] (4)	Distance[a] (1)	Width (2)	Height[b] (3)	Altitude[b] (4)	Distance[a] (1)	Width (2)	Height[b] (3)	Altitude[b] (4)
200	1,000	0		5,200	2,500	100		10,200	4,000	200	
1,200	1,300	20		6,200	2,800	120		12,200	4,600	250	
2,200	1,600	40		7,200	3,100	140		14,200	5,200	300	
3,200	1,900	60		8,200	3,400	160		16,200	5,800	350	
4,200	2,200	80		9,200	3,700	180		52,200	16,000	1,200	

[a] Distance in feet from the zero end of the runway. At the zero end, the width (Col. 2) is 1,000 ft and the height (Col. 3) is zero. [b] Height in feet above the zero end of the runway. To convert values in Col. 3 to altitudes (feet above mean sea level), add the elevation of the zero end, at a given airport, and enter the result in Cols. 4.

Altitude contours may be drawn and are comparable with the surface contours shown on government maps. From the airmen's point of view, it seems better to use altitudes, because aircraft are flown by reference to them rather than to slope ratios.

The "horizontal surface," under current CAA regulations, is described as a plane, circular in shape, with its height 150 ft above the "established airport elevation," and having a radius from the "airport reference point" varying with the service classification of the airport. The "established elevation" of an airport is defined as the highest point of the usable landing area. The "airport reference point" is defined as a point at the approximate center of the airport landing area. The control tower is frequently used as the reference point. The position of this point also should be fixed by giving its state co-

TABLE 2.—ELEVATIONS FOR TURNING-BOWL SURFACES (CONTINENTAL TYPE AIRPORTS), IN FEET

Line	Elevations[a]	Radius from Airport Reference Point (Thousands of Feet):					
		0 to 10	10 to 11	11 to 12	12 to 13	13 to 14	14 to 15
1	Height above established airport elevations	150	200	250	300	350	400
2	Altitude above mean sea level						

[a] To correct values in line 1 to altitudes, add established elevations at the given airport, and enter the result, rounded to the next highest 10 ft, in line 2.

ordinates. The "horizontal surface" is referred to a plane different from that of each runway end (Fig. 3).

Extending outward and upward, from the periphery of the "horizontal surface" is a "conical surface" with a slope ratio of 1 on 20, its horizontal dimensions varying with the service classification of the airport.

To simplify the description of these surfaces further, the writer proposes that they be combined in one tabulation and known by a simple name, such as the "turning-bowl surface" (Table 2).

"Transitional surfaces" (Fig. 4) are defined as inclined planes with a slope of 1 on 7 measured outward and upward at right angles to the runway center line. These surfaces are designed to merge, gradually, the approach surfaces with the "horizontal and conical surfaces" (or the bowl surface if the writer's suggestion is followed). The adoption of tabulated altitudes for the "approach surface" should cause little or no difficulty in defining the "transitional surfaces" by the usual slope-ratio method. Transitional surfaces usually are limited in extent and the effect of curvature of the earth is not important. It should be noted that under current regulations the transition surface just

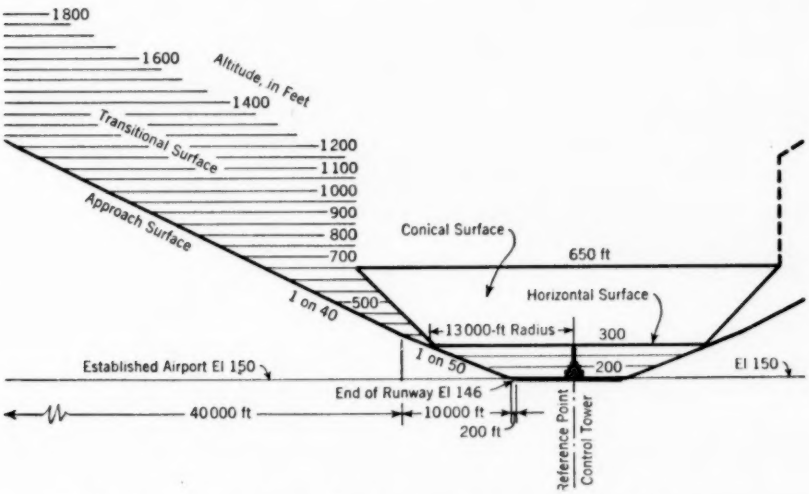

FIG. 3.—HORIZONTAL AND CONICAL SURFACES, INTER-CONTINENTAL TYPE AIRPORT (REGULATIONS, CIVIL AERONAUTICS ADMINISTRATION)

outside the turning bowl begins with a vertical face nearly 500 ft high which does not permit tying the altitude contours of this transition surface into those of the turning bowl.

In addition to the requirements previously stated, *Technical Standard Order No. N 18* lists (under Section B) limiting heights of objects that may be considered obstructions to air navigation "unless special aeronautical study indicates otherwise." The method of defining the height of these objects above runways is the same as that proposed by the writer for the imaginary surfaces—namely, by listing heights which, when added to the elevation of the runway end or other reference points, give altitudes. Here the resemblance ceases. Alternate limitations are given in heights above ground and the tabulated distances are given in statute miles rather than in feet. Also, the tabulated distances in the case of instrument approaches are given in statute miles

from runway ends and in all other parts of the airport are given in statute miles from the airport reference point. One attempt to present these regulations graphically or mathematically for inclusion in a zoning ordinance is enough to discourage the most ardent zoning advocate. Assuming, however, that they

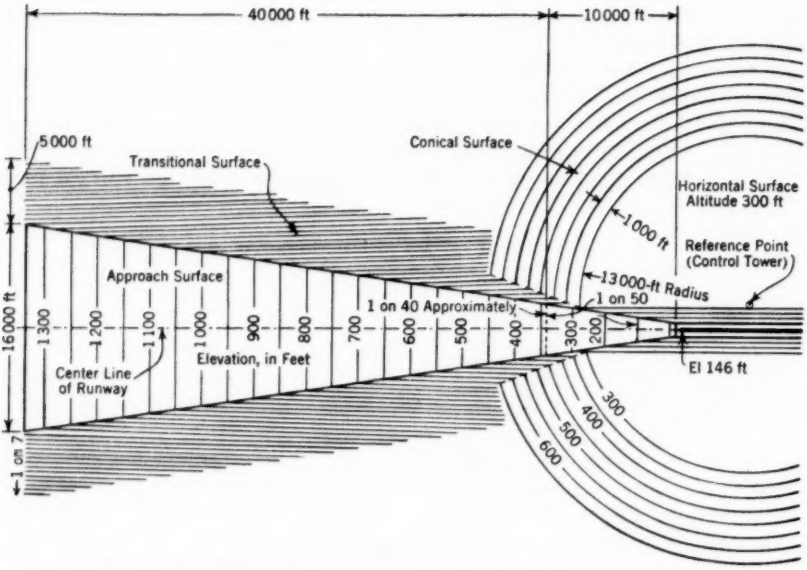

FIG. 4.—APPROACH SURFACE, INTER-CONTINENTAL TYPE AIRPORT (REGULATIONS, CIVIL AERONAUTICS ADMINISTRATION, BASED ON AN ESTABLISHED AIRPORT ELEVATION OF 150 FT

are justified, there seems to be no reason why the requirements should not be tabulated in feet from the airport reference point and in altitudes comparable to other requirements discussed in this paper.

There are further limitations of objects "whose elevation would increase the final approach minimum flight altitude within a civil airway" and "within certain established Military Coastal Corridors." The administration of the requirements of Section B presupposes that there are zoning officials capable of performing "special aeronautical study," with zoning powers extending far beyond the limits of the airport. The average zoning commission does not have such powers or such a staff. The writer does not know of a single case in which the requirements of Section B have been written into a zoning ordinance.

A further commentary on *Technical Standard Order No. N 18* is that many of the existing airports cannot come close to meeting the requirements, and the available sites for new airports meeting the requirements are difficult to find. There seems to be no real reason why the engineer should not prepare his zoning map and descriptions in the simplified manner advocated in this paper. Officials of the CAA could have no valid objections because the adding

of increments of altitude for "approach surfaces" results in a slightly flatter approach slope than does the slope-ratio method.

The requirements for military airfields have led to the establishment of different criteria for their approaches (Fig 5). Air Force Regulation 86-3 sets

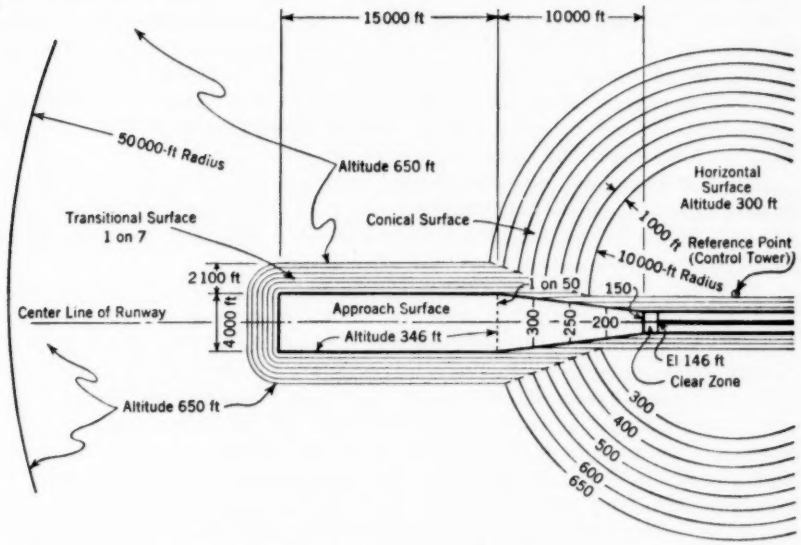

FIG. 5.—INSTRUMENT RUNWAY, MILITARY AIRFIELD, BASED ON AN ESTABLISHED AIRPORT ELEVATION OF 150 FT (REGULATIONS, U. S. AIR FORCE)

forth dimensional criteria for United States Air Force airfields. Air Force requirements are stated in somewhat simpler terms than those for civil airfields, but the dimensions are entirely different. A "clear zone" at the end of each runway is defined as

> " * * * the area immediately adjacent to the end of a runway which has been cleared of all above-ground obstructions and graded to prevent damage to aircraft undershooting or overrunning the runway. The standard clear zone dimensions are 1,000 ft long (measured along the extended runway center line) and 1,500 ft wide (750 ft on each side of the extended runway center line).

Beyond the clear zone is an "approach zone" which is an area beyond each clear zone, extending on the ground for a distance of 25,000 ft along and symmetrical about the extended center line of the runway. The width of the approach zone at the end of the clear zone is 1,500 ft; it flares to 4,000 ft at 10,000 ft from the end of the clear zone; and it remains 4,000 ft wide for the additional 15,000 ft.

The "approach surface" is an imaginary plane covering the "approach zone," beginning at the end of the "clear zone" at the elevation of the end of the runway and rising over the "approach zone" on a slope of 1 on 50 (known

as the glide angle) for a horizontal distance of 10,000 ft (200 ft above the elevation of the end of the runway). From this point the controlling elevation of the approach surface remains at 200 ft until the end of the approach zone (25,000 ft from the end of the clear zone).

In the case of an "airfield reference point," "established airfield elevation," "horizontal surface," and "conical surface," Air Force definitions are roughly similar to those of the CAA. Air Force regulations tabulate widths and heights in the manner recommended by the writer for civil airfields. However, the "horizontal surface" is referred to as a "plane" and the approach surfaces are given as planes with a slope of 1 on 50. These regulations could be made much simpler to administer by specifying altitudes.

The Air Force has succeeded in specifying the type of hazard covered by Section B of *Technical Standard Order No. N 18*, in a simplified manner, and the only improvement indicated would be to make clear that altitudes above mean sea level are meant, rather than slope ratios.

Obviously, Air Force approach surfaces, beginning 1,000 ft from the runway ends (compared to 200 ft in civil airfields) are somewhat more restrictive than CAA regulations. The reason for this is the much flatter climbing slope. A commerical plane traveling 125 miles per hr and climbing 500 ft per min will have a steeper climbing slope than, say, a jet plane climbing at the same rate with a much higher forward speed. However, the military aircraft of today determine many of the characteristics of the commercial planes of tomorrow, and it is difficult to understand why the requirements of both should not be correlated into joint Army-Navy-Air Force-Civil zoning regulations, simplified as far as possible. In one project, the airfield is zoned approximately according to CAA regulations. An important Air Force base was contemplated which required Air Force zoning regulations. As a further problem, the obstruction map prepared by the United States Coast and Geodetic Survey (USCGS) shows an airport reference point that is several hundred feet away from the point used by the other two. To make matters further complicated, the so-called "horizontal surface" is actually zoned at this airport with a radius of 4 miles; CAA regulations call for a radius of 13,000 ft and Air Force Regulations require that a radius of 10,000 ft be shown on approach drawings.

Avigation easements offer a means of controlling airport approaches and of reimbursing property owners for the damages suffered, without resorting to the outright purchase and subsequent eviction of families from homes to which they may be deeply attached, or from farms or business locations providing their livelihood. Avigation easements usually should be attempted only when zoning imposes real hardship or when they may be obtained at less cost than outright purchase would entail. Avigation easements also may be the only solution where political boundaries or lack of enabling legislation make zoning impracticable. Simplified maps and descriptions should be used in the taking of avigation easements in the same manner as in zoning practice.

Summary

Summing up briefly, the desirable features of airport zoning maps are as follows:

(1) Airport reference point and runway ends fixed by state coordinates;
(2) Horizontal limits of imaginary surfaces fixed by radial distances, in feet, from the airport reference point, wherever possible;
(3) The elevation of all runway ends referred to mean sea level;
(4) The number of imaginary surfaces reduced to a minimum with altitudes referred to mean sea level; and
(5) Ground contours and landmarks shown in dashed lines.

A zoning map meeting these requirements can be plotted on other maps without recourse to field work and may easily be used by engineers and zoning ordinance administrators.

Even with the best of airport approach protection, vigilance and administrative effort will always be required to prevent the encroachment of growing trees and man-made hazards. It is not believed that any existing airports live up to their ordinances completely. By doing so, however, safety features of the airport and its neighbors are enhanced, the capital investment is protected, the capacity of the port is maintained, and early obsolescence may be averted.

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